Studies on Enriched Food

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In 1936, the author found that we could remove a small quantity of oxygen which remained in beer and preserve beer from denaturation and moreover prevent the haze of beer by means of adding vitamin C to beer. But vitamin C was so expensive in Japan 20 years ago that if 15 to 20 mg of vitamin C were added to a bottle of beer (640 ml), the price of beer would increase seven to eight-fold. At present, this can be put in practice very easily and it seems to me that beer brewers in Japan are making the best use of my idea.

We also succeeded in making enriched rice for the first time in the Laboratory of Nutritional Chemistry, Agricultural Faculty, Kyoto University, and have continued to do our best about the betterment of it until today. Enriched B_1-rice is adopted widely in Japan and contributes to the promotion of the health of the Japanese people.

The author also state his humble opinion about the enrichment of calcium and the actual state of enriched foods in general in Japan expecting their steady development.

When the precautionary medicine and the public hygiene advance, and the people enlarge their stock of knowledge of nutrition and put it in practice, patients naturally decrease.

The more patients decrease and the slacker the business of physicians becomes, the happier the people are.

When the standard of morality in the populace is elevated and only the smallest number of policemen are necessary to maintain public order, people are very peaceful.

The society which has need to establish as many police-stations, prisons and hospitals as possible is not a desirable thing after all.

Education and religion are performing their constructive missions to elevate the standard of morality in the people.

It is more important for us to educate and influence people so as not to become wicked men, than to let them commit a sin and to establish and complete equipments to isolate those sinners.

We should rather try constructively to keep peoples health than make them sick and establish or complete hospitals to cure them. In this way, nutritional science is very important.

In the Art. I of the Law of Nutritional Improvement which was passed the Diet on 31st July 1952 it is expressly provided for that, "This law aims to contribute to promote national welfare by means of striving for the elevation of ideas of nutritional improvement of the people, the inquiry into the nutritional conditions of the people and the maintenance and the development of the health and the physical strength of the people devising necessary steps about the

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betterment of the nutritionalconditions of the people." As a method to better the nutritional conditions of the people, enriched foods were adopted and such nutrients which were apt to be lacking as vitamin A, B_1, B_2, C and D and niacin, calcium and iron were added to those various foods as rice, wheat flour, *miso* (bean paste), soy, milk, butter etc. It is advisable to be supplied such staple foods as rice and wheat after they were fully enriched and pieced out their insufficient nutrients and made almost perfectly nourishing foods by suppliers, as water from the waterworks is supplied after it was sterilized at its source. Thus, the health of the people will be promoted without being aware of it, and rich and poor, learned and ignorant alike can participate in the benefits.

Accordingly, we think it is one of the important plans to guarantee a healthy and civilized life of the nation to invent enriched foods which will not turn tasteless at all, and can be stored longer than ordinary foods and do not saddle consumers with too much expenses.

But recently, among dealers in provisions there have appeared in rapid succession those who cannot make out the meaning of the enriched foods but use them in order to promote their own interests only. Therefore the author thinks we should again make people understand the significance of enriched foods, and as the good and bad are all in a jumble we should also weed out these bad dealers and realize the expected results. So, the author earnestly hope to develop intellectual faculties of general consumers by giving them an outline of the enriched foods, and expect they can judge correctly by the good understanding.

Recently we have succeeded to piece out insufficient nutrients accurately and lighten a burdon of the people, because in Japan the technique to synthesize vitamins has rapidly attained to proficiency in late years, and they have declined in price remarkably as a result of large production. It is a matter of course that we call the method to piece out insufficient valuable nutrients which were lost during we were working upon natural foods, " Enrichment of Foods ", and that we also call the foods made by the above-mentioned method, " Enriched Foods".

As stated before, in order to enrich foods, we must satisfy the following three conditions.

I) The nutrients which were added and enriched should not be lost during the enriched foods are made or stored.

II) The enriched foods should not turn tasteless at all.

III) The enriched foods should not saddle consumers with much more expenses than ordinary foods.

Moreover, it is desirable for us to make enriched foods storable longer and more tasteful by the various ways of enriching and as it were, to kill two hares with one stone.

The enrichment of foods was originated and developed in the U. S. A. In 1936, the Council on Food and Nutrition was established by the American Medical Association and a question of adding vitamin D to milk and that of mixing table salt with iodine were then discussed. In December of the year, the Council on Food and Nutrition changed its name to the Committee on Foods and discussed

the question of the so-called enriched foods. In December 1938, the joint congress of the Committee on Foods and the Committee on Food and Nutrition in the American Council on Pharmaceutical Chemistry met and brought up for discussion the problem of adding vitamins to staple foods including wheat flour. The Minor Committee on Medical Nutrition in the National Council on Science recommended to add vitamin B_1 to all the cleaned wheat flour to enrich it which the U. S. Army and Navy would purchase. Just then, the World War II broke out and this Committee developed into the National Nutrition Conference for Defence. At present, 80% of the wheat flour in the U. S. A. are enriched and in about 26 states, being established by the law to enrich wheat.

There is a sort of enriched rice called "Premix Rice" which was invented by R. R. Williams, an authority on the synthesis of vitamin B_1 and Furter. They sprayed the solution of vitamins on rice and dried it.

Then they made a cort like a varnish from the alcohol solution of zein, the maize protein. Mixed the ordinary rice with the enriched rice prepared by the above-mentioned method, they sent the rice to Bataan Peninsula in the Philippines and 90,000 people tasted the sample food in experiment. It is reported that in half a year since the experiment began, beriberi patients rapidly diminished and beriberi mortality even reached zero.

Though the question of the enriched foods has generally been discussed in the last few years, it has been studied for a long time.

One of my friend, who is at present a member of a certain beer brewery company, had once racked his brains for a counter-measure to settle the question of the haze (Trübung) of beer. This was construed that when beer was stored in summer, only 0.02 ml of oxygen which were remained in a bottle of 640 ml of beer deteriorated the protein in beer and precipitated it and consequently they made the beer haze. Upon this, the author thought of that as vitamin C has a strong reducing power owing to endiol radical $-\overset{OH}{\dot{C}}=\overset{OH}{\dot{C}}-$, we could easily extinguish the remained oxygen and prevent the deterioration and the haze of beer after all, by means of adding a little amount of vitamin C to beer. Being presented with a considerable amount of beer from this beer brewery company to our laboratory of the University, we investigated experimentally the effects of vitamin C on beer very minutely and the result came up to my expectations. Members of the above-mentioned brewery company also experimented to authenticate the same result on a large scale, and the experiment was also a success.

As the added vitamin C becomes stabilized by carbon dioxide gas contained in beer and the colored bottle prevents vitamin C from being destroyed by the sunlight, we emphasized the possibility of beer containing vitamin C and inquired into the most suitable amount of the vitamin to be added to beer in various ways.

At the time, in 1937, of course we had not such a term as enriched foods, we called our method as "the way to prevent beer from oxidation" and recommended the adoption of this way to the brewer of beer in Japan. I often look back upon those days when I was struck with an idea of the so-called enriched

foods 20 years ago and tried to put it in practice, and together with my friend I feel yearning for the days. In those days, however, to our great regret, the price of the synthetic vitamin C was more than 150 yen per gram and that of a bottle of beer was only 38 sen, and it costed 2 or 3 yen to add 15 to 20 mg of vitamin Cto a bottle of beer, and my idea was abandoned as a romantic vision of a scholar who was ignorant of the world. But today, the situations have changed completely, and the price of vitamin C is under 10 yen per gram and that of beer is more than 100 yen per bottle. Consequently, it is very easy to put the idea of enriched beer in practice at present. If brewers of beer are utilizing my above-mentioned idea, that would be quite a piece of luck for me.

When we began to study vitamin B_1, we tried to inquire into the mechanism of the formation of the vitamin in the leaf part of the rice-plant. In 1947 and 1948, we determined vitamin B_1 contents of leaf part and ear part of the rice-plant in each growing period, that is to say, in tillering, pre-earing, earing, flowering, fructifying, ripening, completely ripening and withering period, and we revealed the ratio of free-vitamin B_1 to ester-vitamin B_1 and studied the physiological meaning of vitamin B_1 in plant.

Making a step of this work forward, we laid strong foundation for the invention of the enriched rice in our country by means of establishing the principle of the "acid-parboiled rice", that is to say, the principle to remove natural vitamin B_1 contained in rice-bran and embryo to the endosperm by means of soaking rice in acetic acid. Then we completed enriched B_1-rice and expressed the result at the academic circles in May 1949.

After this, we published the contents of our study very minutely in a scientific organ under the titles of "Studies on B_1-rice (so-called Acid-Parboiled Rice)" and "Studies on Nutritional Enrichment of White Rice."[1)2)]

On the other hand, we got a goverment-owned patent of a method to enrich the nutritive value of polished rice[3)]. When the enriched rice, which had been thus perfected by an entirely original idea, was about to be made in a pilot plant, in February 1951, R. R. Williams came to Japan and lectured "On the problem of beriberi of rice-eating races and the enrichment of rice". Spurred by this lecture, many introductory remarks of the enrichment of foods appeared in scientific organs successively, and in May 1952, the Headquarters of the Economical Stabilization advised about the enrichment of foods, and in July of the same year, the Bill of Nutritive Improvement passed the Diet, and the people in Japan were interested in this problem more and more deeply, and hoped to put the enrichment of foods in practice as early as possible.

As we showed in Table 1, it may easily be understood that where we take 400 grams of unpolished or half-polished rice, we can partake of the amount of vitamin B_1 above the minimum levels necessary, but the same quantity of polished rice remarkably lacks in the vitamin. And we must allow for losses of vitamin B_1 of rice in washing and cooking.

They polished rice which prevents eaters from falling ill of beriberi is the enriched polished rice. It may be pardonable that just after the World War II, consumers of rice in Japan polished their rice for themselves.

Table 1.

	Vitamin B_1 contents in 100g of rice
Unpolished rice	0.40 (mg)
Polished for 5%	0.30
Polished for 7%	0.25
Polished rice	0.07
Enriched rice	120.00

It is desirable for us that foods should be tasteful, nourishing and cheap. We hope we would re-examine the problem of the enrichment of foods seriously in order to act up to the above-mentioned desires.

The Japanese method to enrich rice is as follows. Polished rice is soaked in a 1% acetic acid containing synthetic vitamin B_1 in solution. According as the contents of vitamin B_1 in the solution, rice can be made containing any amount of vitamin B_1 as desired. After soaking rice in the solution, the rice is drained, steamed and dried in order to prevent vitamin B_1 which was penetrated into the endosperm from losing in washing and cooking.

Enriched polished rice made by the above-mentioned method is tasteful and more resistible to rice weevil than ordinary polished rice. When we take enriched rice and ordinary polished rice in the weight ratio of 1 to 200, we can partake of enough amount of vitamin B_1 to keep our health relishing the tasteful polished rice.

Japanese enriched rice above-mentioned has many merits as compared with "Premix Rice" of R. R. Williams, but its weakest point is a crack of the grain of rice. A crack makes an ill figure and broken rice, moreover, cracked rice often lose the enriched nutrients in washing. With a view to eliminate these defects and produce enriched rice easily the author studied as follows.[4] When

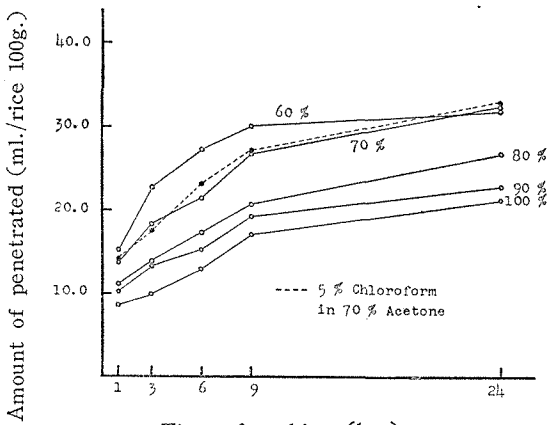
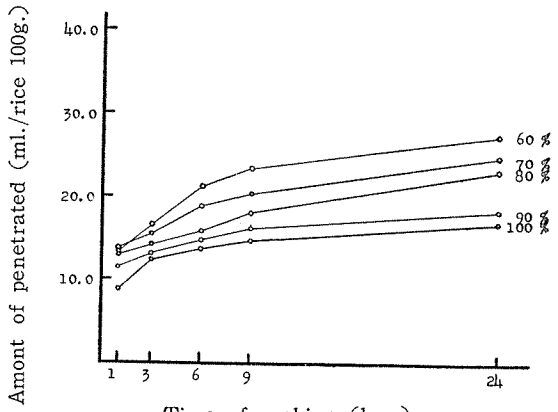


Fig. 1. Penetration of acetone.



Time of soaking (hrs.)
Fig. 2. Penetration of ethanol.

soaked in acetone, ethanol or hloroform, in organic solvent, for example unlike the case to be soaked in water, no grain of rice cracks at all. Moreover, the auther found out that though these organic solvents were dissolved in water to 30 % or to 40 %, also not a grain of rice cracks.

As shown in Figs. 1 and 2, aqueous acetone and ethanol penetrate into every

Table 2. Solubility in organic solvent of Vitamin B_1 derivative (Gram per 100 ml. ; 30 °C).

Solvent conc.		B_1-derivative			
		B_1-HCl	DBT	Cetyl-B_1	B_1-naph. *
Acetone	100%	0	1.08	0.16	0
	90	1.76	2.18	0.96	0.004
	80	3.20	1.76	1.24	0.047
	70	10.81	1.03	0,97	0.16
	60	22.07	0.57	0.58	0.362
Ethanol	99%	0.22	0.35	1.82	0.044
	90	2.14	0.68	2.20	0.025
	80	8.59	0.70	2.37	0.105
	70	20.40	0.61	1.65	0.181
	60	34.27	0.36	0.85	0.31
Chloroform	100%	0	27.67	2.12	0
Chloroform : Acetone	9 : 1	0		3.05	0
	8 : 2	0		1.52	0
	7 : 3	0		0.85	0
	6 : 4	0		0.51	0
5% chloroform in 70% acetone		0	1.79	3.31	0.13

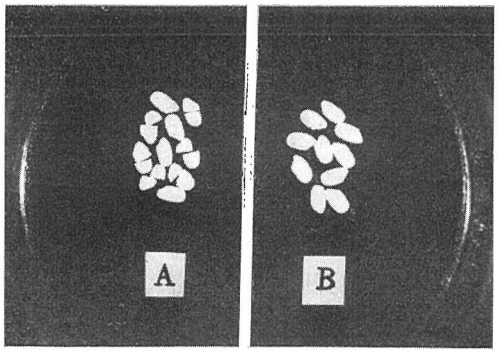
*Thiamine naphthaline-2,6-disufonic acid.

grain of rice very well. Derivatives of vitamin B_1 which are insoluble in water, for example, DBT (dibenzoyl thiamine), thiamine dicetylsulfate and thiamine-naphthaline-2, 6-disulfonic acid are, as shown in Tables 2 and 3, much soluble in acetone, ethanol and chloroform, and we can prevent the enriched rice from losing vitamin B_1 in washing and cooking completely by means of making it adopting these organic solvents.

Table 3. Solubility in Acetone-Water of DBT (Gram per 100 ml.).

Temp. (C)	Acetone (v/v%)				
	100	90	80	70	60
30	1.08	2.26	1.75	1.03	0.57
50	2.90	5.28	5.39	3.14	1.62

As enriched rice thus made does never crack, at all we can omit the process to steam it. This is an improvement very suitable for the production of enriched rice on a large scale.



A···Acid parboiled rices method
B···Organic solvents method

As vitamin B_1 is necessary for metabolism of carbohydrates, it is most desirable to enrich rice, wheat and barley which run quantitatively parallel to the amount of starch and the calorie taken into the body. From the view-point of nutritional science, it is a temporary expedient to enrich soy. The former method to enrich rice was a little too complicated and it had such defects as above-stated. But the author believes the method to enrich rice has completely been improved by the invention of the process of organic solvents.

These solvents can be perfectly collected again by charcoal, and as to the care for fire, according to the common sense of the industrial circles, we can set our mind at ease.

There are some who advocate that they need not supplement their necessary amount of vitamin B_1 by enriched rice, but they can partake of it by their foods

to eat with rice, a side dish. But it is almost impossible for us to supplement the necessary amount of vitamin B_1 of 1.2 mg by a side dish.

Others maintain that as they take vitamin B_1 in tablets they also need not eat enriched rice. But the vitamin is a sort of nutrients and not a so-called medicine. It is the best way to take nutrients in foods not in tabloid form. The author wonder what proportion of the whole population of 90 million in Japan can daily take such a costly medicine whose charges can pay an outlay for advertisements, packing charges etc. Contrary to medicine, enriched rice is much cheaper than they are and by taking it, we can daily partake of the vitamin unconsciously, irrespective of age.

Under the existing nutritive condtions of the Japanese people, the problem of calcium is more important than that of vitamin B_1. Taking the ratio of Ca/P

Result of National Nutrient Survey (1955) Amount for a day/head

	Necessary amount	Whole country			Cities			Rural districts		
		May	Aug.	Nov.	May	Aug.	Nov.	May	Aug.	Nov.
Calorie	2180	2080.3	2040	2178.8	2008.5	1960.1	2064.6	2146.9	2123.7	2282
Animal protein (g)	24	21.3	0.20	25	24.7	23	27.4	18.2	17.3	22.9
Total protein (g)	73	68.9	66.1	72.6	69.8	66.4	72.2	68.1	65.8	73
Fat (g)	30	19.2	19.7	21.4	22	22	23.4	16.7	17.7	19.6
Calcium (mg)	1000	336	320	349	337	325	348	334	316	350
Iron (mg)	10	15	13	14	16	12	13	13	14	15
Vitamin A (I.U.)	3700	1585	939	1681	1408	992	1900	1749	891	1483
B_1 (mg)	1.2	1.13	1.18	1.2	1.16	1.16	1.14	1.1	1.2	1.25
B_2 (mg)	1.2	0.74	0.6	0.68	0.75	0.61	0.7	0.73	0.59	0.67
C (mg)	60	70	62	96	72	59	86	69	64	105

into consideration, the author thinks that it is desirable to add calcium in the form of calcium carbonate to the foods. When vitamin B_1 hydrochloride and calcium carbonate coexist, vitamin B_1 becomes unstable, but we can be free from anxiety by adopting various sorts of insoluble vitamin B_1.

The indispensable amount of calcium is 1.0 gram per day and as the amount is so large, it is very difficult for us to add enough calcium to foods without spoiling their taste.

I am also trying to device good methods of enrichment of calcium and some of them are as follows.

In the first method we adopt the formative character of α-starch. As the former of the tablet, lactose is generally used but this material is very high in price. As I had found that α-starch has a distinguished property of forming the tablet which β-starch (raw starch) had not, and I published this merit of α-starch as a former of the tablet[5].

When we take a tablet formed with α-starch, as it is easily undergone the

action of ptyalin and maltase in the saliva we can take a large and necessary amount of calcium. This character of α-starch should be taken into consideration in case of the enrichment of calcium foods.

In the second method, I make a new sort of condiment mixing indispensable amino acid, calcium and various vitamins in good proportion whose taste is synthesized to be more delicious than a dried bonito, a tangle and small fishes used to prepare stock in Japan. The condiment should be made so as to be made dissolved in water in a cooking pot as soon as it is heated. This is a solid condiment combining taste with nutrition. *Miso* soup can be made with ease when we use it. As the solubility of calcium is low, it is an idea to take necessary amount of calcium by this means.

We believe it important to take nutritive value, taste and prevention against putrefaction into consideration as a means towards spreading a more general knowledge of the enrichment of foods.

To our regret, under existing circumstances of the enriched foods in Japan, consumers cannot understand how they are enriched.

There are some which are called by "Milk containing vitamins" but never state the sort and the quantity of vitamins contained. We think it conscientious to state clearly at least the minimum quantity and the names of nutrients contained in the foods. If the quantity of the nutrients contained in them is more than the minimun quantity specified, it can be construed as a service rendered to consumers.

Those who exploit the enrichment of foods with vitamins and minerals for selfish purposes put seriously enriched foods to much trouble. It will meet our ideals to put the enrichment of staple foods in practice at the expense of the state.

It is most earnestly to be hoped that through the betterment of the consumer's knowledge of nutrition and under the fitting direction of the authorities, the enrichment of foods will be put into execution more widely and seriously.

REFERENCES

(1) K. Kondo, H. Mitsuda and K. Iwai, *Vitamin*, **2**, 134, 264 (1949), **3**, 155 (1950), **4**, 203 (1950); *Bull. Res. Inst. Food Sci., Kyoto Univ.*, No. 3, 1 (1950), No. 6, 57 (1951), No. 10, 1, (1953) ; *Bull. of Kansai Part of Food and Nutrition*, No. 3, 9 (1950).

(2) H. Mitsuda, *J. Japanese Soc. Food and Nutrition*, **3**, 7 (1950).

(3) K. Kondo, H. Mitsuda and K. Iwai, Japanese Patent, No. 186,768 (1951).

(4) H. Mitsuda, *Vitamin*, **12**, 355 (1957) ; *J. Japanese Soc. Food and Nutrition*, **10**, 19 (1957).

(5) Read before the meeting of the Nutrition and Food Society on April 29th, 1953 and also before the meeting of the Agricultural Chemical Society held at Hokkaido University on August 8th, 1953 ; H. Mitsuda, This Bulltein, **33**, 114 (1955).